ART. VII.—*Researches upon the Structure and Functions of the Ciliary Processes.* By R. FRASER MICHEL, M.D., Charleston, S. Carolina.

WHILE among the litigated points of anatomy and physiology, there are many questions rendered particularly intricate from the numerous bearings which they present, there are others which require but the scrutiny of an anatomical eye to lead us almost naturally to the physiological inductions which appear to follow as the sequel. This is, perhaps, the nature of the examination into which we are about to enter.

While studying absorption, and believing from the concurrent testimony of several physiologists, and the plausibility of their researches, that the venous system plays a prominent part in the discharge of this important function, the eye presented itself to me, as an organ said to be totally deprived of lymphatics, and which seemed to furnish an example confirmatory of this assertion. The question arose, whether the eye really possessed any peculiar vascular arrangement which distinguished it in this respect from any other organ, as it was deprived of lymphatics for the accomplishment of absorption. A careful anatomical examination was instituted, by which I purposed to determine the relations which exist between the constituent parts of that organ, and their peculiarities of structure.

In undertaking this subject, and making references to those works which were inservient to my purpose, I found that I had engaged in a vast field already explored by those whose names are destined long to reign with oracular authority over anatomical questions. Indeed, the names of *Sœmmering, Linn, Arnold*, and others, appeared to preclude the possibility of my determining anything positive with regard to this problem. But as from every subject, truth may be said to radiate like the beams of light in various directions, the hope has been encouraged, that it is given to every one to view it in some one of those numerous phases which may possibly have escaped the scrutiny of the imposing authorities whose names have been mentioned above.

Proceeding, then, without further preliminaries, to the discussion of a subject no less intricate than interesting, we will, for the facilities of description, and the more orderly exposition of the facts which support our views, comprise, what we have to say, under two sections: examining under the first head such parts of the eye, the complexity of whose structures fails not to attract our serious attention; and under the second, making such physiological inferences from the structure of these respective membranes, as may elucidate the functions they discharge.

As our remarks will therefore particularly bear upon the function of absorption, and the nutritive acts, as they are performed in the eye, attention will be almost solely directed to the *choroid coat* and its appendages, the *iris* and *ciliary processes*, while the hyaloid membrane and body will also engage our time so far as they may be connected with the vascular arrangement of the organ.

After my first examination of an eye, prior to my attention being especially engrossed by this subject, I found that my impressions concerning the choroid coat were by far the most striking. I was no less impressed with that peculiar deposit—than which there is nothing more singular in the whole economy—investing the entire membrane, than that there should be so large a reticulum of blood-vessels in so small a space. Indeed, the vascularity of this coat is such, that the learned Prof. Cruveilhier justly remarks, that the words *choroid* and *vascular* are synonymous.

Of the general direction and relation of this vascular layer it is needless to speak, as this would be but reproducing what every elementary work on anatomy contains; but of its anterior termination and structure, concerning which there is such diversity of opinion, we will furnish some account.

Since the days of the celebrated injector Ruysch, the choroid has been regarded as composed of three distinct layers, which are readily exhibited when recourse is had to the proper modes of preparation. The outer layer, which is manifest to the unassisted eye on a choroid coat that has macerated a while, is formed of a multitude of blood-vessels held together by cellular tissue, and when examined with the lens, present a tortuous direction, running into centres whence radiate a number of convoluted capillaries. From the multiplied centres, the rendezvous of these arborescent ramifications, the vessels which are altogether composed of veins, have been called venæ vorticosæ, and contrast very strikingly with those of the layer beneath, which is made beautifully conspicuous when both are injected; the lamina immediately beneath is arterial, its vessels coursing lengthways towards the anterior part of the eye. This is the layer which was first so beautifully injected by Ruysch, and has since borne his name, *tunica Ruyschiana.* This part, when well injected, gives to the choroid coat the appearance of a sheet of gold; very excellent representations of this are given in Zinn,* and Sœmmering.† The next lamina which forms the inner part of the coat in contact with the retina, is not readily exhibited in the human eye, though in the sheep it is always easily demonstrated. This is the *membrana pigmenti.* After maceration, a separation of this portion is most easily effected by commencing at the tapetum lucidum, where the layer possesses the greatest thickness. Conveyed beneath the microscope, it presents the beautiful appearance of a hexagonal tesselated pavement; each hexagon being a cell in which the granules of pigmentum are secreted, that portion of its extent forming the tapetum being void of pigment globules, though the cells exist.

* Descriptio Anatomica Oculi Humani, Fab. iv. Figs. 1 et 2.

† Icones Oculi Humani; Explicatio Fabulæ quintæ, Figura septima.

Now after this cursory view of the several constituent parts of the choroid, let us examine the mode of their termination at the anterior part of the eye. Indeed, this is the question which it behoves us to examine, and its careful consideration will form the principal object of the present remarks.

The generally received opinion is that there is a mutual reception of the ciliary processes, iris, and ciliary ligament, and in such a manner we are told, as to allow of a ready separation of the iris from the rest of the choroid, upon a knowledge of which assertion, rests one of the operations for artificial pupil. But the exact mode of termination of these several structures, nay, even their exact nature, is by no means settled.

A signal illustration of the diversity of opinion on this subject may be found by perusing a work recently published by a distinguished physiologist of Germany, Rudolph Wagner, who, in speaking of the *ciliary processes*, calls them *muscular*, an opinion now professed by few, and which is certainly in formal contradiction with the result of my observations, as far as they have extended among several classes of animals, the sheep, ox, dog, cat, and in the human species.

Whatever be the mode of union of the *iris* and *choroid*, one fact may be easily established, which is, that the adhesions between the two are far more intimate than is generally believed. To convince one's self of this fact, we need but observe, in dissecting an eye, that the *choroid* and *iris* continue still to protect the humours after the removal of the sclerotica and cornea,—there is only a slight adhesion of the iris and choroid with the sclerotica. This connection appears to me to be of a ligamentous character, particularly in the eye of the bird, and in the sheep, where the anterior layer of the iris, which is clearly muscular, seems to give off a multitude of tendinous slips attached directly to the choroid, under the form of a circular white line, improperly called "*annulus gangliformis, seu ganglion annulare*," by Sœmmering.* This is no ganglion, but a ligamentous tissue, deserving the appellation which it often bears of ciliary ligament, as it unites the muscular, or anterior layer of the iris with the choroid, just as the posterior layer, which I consider as altogether vascular, is directly continuous with that tunic. The pulpy appearance which the ciliary ligament may sometimes assume, is apparently due to the rupture of its slight attachments with the sclerotica, for this circumstance leaves a somewhat similar appearance upon the corresponding part of the sclerotica.

Such, then, is the nature of the ciliary ligament: a band of union between the muscular, or anterior layer of the iris and the choroid, adhering slightly to the sclerotica, but firmly to the choroid, from which it is torn, but does not naturally separate, in operating for artificial pupil. But the posterior layer of the iris is a direct continuation of the choroid, and therefore essentially vascular; the blood-vessels of the latter running forward and downward, passing over and concealing the interior surface of the ciliary ligament, for which reason this structure is much less visible on the inner than outer surface.

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* Icones Oculi Humani; Explicatio Tabulæ quintæ, Figura septima.

This direct continuity of the framework of the iris with the choroid, explains the constant integrity of the two membranes after removal of the sclerotica, as they literally are one and the same. This direct continuation of the blood-vessels into the iris, is particularly visible in injecting the eye of a fœtus whose pupillary membrane still exists, as may be seen in the plates accompanying Jules Cloquet's monograph on this subject.* However, I may here observe, and would call particular attention to the remark, that all the blood-vessels do not pass into the iris. Of this I have had repeated opportunities of satisfying myself by injecting the arteries of the choroid tunic.

The ciliary processes, the nature of whose structure has been so variously interpreted, is positively vascular, and present so singular an arrangement of its vessels, that my surprise is great in observing the uncertainty of most authors on this subject. It is true that their nature, and the office they probably fulfil, were anticipated by ancient writers; but of this we have nothing but the most hypothetical accounts.

The first experiments which were performed on this subject, were by Ribes, in a series of essays published in 1814 and 1816;† and here I must acknowledge great assistance from the writings of this accurate and laborious investigator, many of whose researches I am proud to have been able to verify, as I am now more than ever convinced, they carry with them the stamp of truth.

Some of the many views entertained with reference to the function of the ciliary processes, were first, that they were destined to move the iris, or to fix the crystalline lens, over which they exerted that influence which allowed the eye to adapt itself to various distances. It was believed again, that they secreted the black pigment which invests the choroid and posterior face of the iris. It is needless to confute these assertions, for the muscularity of the iris, the membrana pigmenti, and the separation of the ciliary processes from the crystalline lens, are overwhelming arguments to the contrary. Moreover, as observed above, these remarkable structures are altogether vascular, the blood-vessels of the choroid coat extending directly into them in the most visible manner, and presenting one of the most beautiful appearances that can be exhibited from injections of any other part of the body. When, indeed, a ciliary process has been divested of that inspissated pigment in which it is disguised, and, placed on a lamina of glass, is conveyed beneath the field of the microscope, we may distinctly discover the presence of a hollow canal, which, when it reaches the free extremity of the ciliary processes, affects a recurrent direction, coursing backwards parallel to the first, so as to form a perfect loop. Eccentric to this loop, there is a fringed arrangement of cellular tissue, which, indeed, may be distinctly seen with the naked eye. Now after a successful injection of coloured ichthyocolla through the common or internal carotid, it will be found that the canal in the ciliary process is an artery derived from the arterial layer of the choroid coat. Again, if we inject by the jugular vein, (which is much less apt to succeed, owing to the fragility of the veins in the choroid,) the injection passes into the fringes of the ciliary processes. The vascularity, then, of these appendages to the choroid is evident.

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* Mémoire sur la Membrane Pupillaire, et sur la Formation du Petit Cercle Artériel de l'Iris. Par Jules Cloquet.

† Mémoires de la Société Médicale d' Emulation.

Before we proceed to the inferences deduced from this fact, let me further remark that on no occasion have I found that the substances used in injections pass into the hyaloid membrane of the vitreous body. I have never consequently seen the hyaloid artery described by Cloquet and others, as passing through this humour to the posterior part of the lens, through the arteria centralis retinæ, easily and fully injected. In these respects do I fully concur with Ribes, who was no more successful in injecting the hyaloid membrane. It is true that, according to Hanover, the *canalis hyaloideus* is pervious only in new-born children, as he never could succeed in injecting it in adults. This would only explain the reason for Ribes' ill success as well as my own, but would in no wise interfere with the conclusions I am to draw, as the consequent obliteration of the vessels of the corpus vitreum is admitted.

Besides these ciliary processes described as dependencies of the choroid coat, there are a distinct series of similar structures connected, as I believe them to be, with the retina; though their presence has been denied by many authors, they are described by others under the improper name of ciliary processes of the vitreous body. They are by no means the depressions of the *Zonula Zinni*, which give that fluted appearance to the canal of Petit, which has led anatomists to term this part of the eye the *canal godronné*. With a good lens in a favourable light, the fringes of these ciliary processes may be distinctly seen, and they are also susceptible of being injected, though I am not prepared to determine whether the injection passes into them through the central artery of the retina, or from any immediate connection which may exist between them and the ciliary processes of the choroid coat. Indeed, there is a mutual reception between the processes of the choroid coat, and those of the vitreous body. It is evidently from this juxtaposition, that the latter became also invested with the pigment, and a communication between these two sets of processes seems very probable.

If I have supposed the processes of the vitreous body to be connected with the retina, it is from their attachment to the zonula zinni, which I regard as a continuation of the arterial or internal layer of the retina. Many of my dissections justify this belief, and some microscopists have followed the nervous pulpy filaments of the retina along this part to the peripheral portion of the crystalline lens. I am inclined to suppose that it is through the zonula zinnii that the capsule of the crystalline lens receives blood-vessels, and that these are derived from the retina, as there has often been an appearance of vascularity about the lens, without any traces of it in the vitreous body.

I am sorry that, while in accordance with Ribes, as regards the non-vascularity of the hyaloid membrane and vitreous body, I find that my observations must be placed in opposition with those of Cloquet and Müller. The latter particularly describes the hyaloid artery as passing through the vitreous body, furnishing to its membrane reaching the posterior capsule of the lens, upon which it is spent. He further mentions a fœtal structure, discovered by himself, under the name of *capsulo-pupillary membrane*, which also receives its blood-vessels from the artery.

Notwithstanding these authorities, I must continue in my belief that the humours of the eye are altogether transparent, being deprived of blood-vessels, which otherwise would intercept the rays of light, or at least materially interfere with vision. Regarding, then, the humours of the eye as completely isolated from the rest of that organ, being enveloped by their proper membranes, which, preserving the character of true serous membranes, are remarkable for their extreme tenuity and non-vascularity, the question arises: in what manner are secretion, nutrition and absorption effected?

Before replying to this question, let us observe that it is not very long ago since the function of absorption, supposed to be the sole prerogative of the lymphatic system, was disputed for by another order of vessels, whose important office was made known to us by the valued experiments of Magendie. This distinguished physiologist proved by a series of experiments, which we cannot here detail, that the veins positively absorb. Again he was conclusive in the further result that, during this process, the veins manifested a peculiar predilection for liquids, which were taken up with the greatest rapidity.

Now, taking the anatomical condition of the eye as the basis of a reply to the above question, and pointing out its alliance to the physiological fact just mentioned, we will at once discover a singular parallel between the office of the choroid coat, and that of the chorion enveloping the fœtus. Indeed, like this latter, the choroid is alone inservient to all the nutritive and secretory processes transpiring in the parts which it envelops, and this might almost be inferred from its extreme vascularity, and the peculiar distribution of its vessels, in those several appendages termed ciliary processes. These remarkable structures are organs of secretion. This will be readily understood, from what has been said of the central arterial loop, and the venous fringes, which together form a ciliary process; for what would be the object of this extraordinary arrangement, were it not to realize some such important office in the vital operations of this perfect organ.

We can certainly imagine that the blood passing through these processes, is subjected to an operation, allowing the secretion of that aqueous fluid, which, by penetrating into the cells of the hyaloid membrane, will constitute the vitreous humour. Moreover, from the evident connection of the processes of the vitreous body with, and their penetration into the capsule of the lens, (a fact verified by Ribes,) we may readily admit a similar operation as going on in this place, which would explain the possibility of capsular cataract, while the lens itself is perfectly transparent.

Now, after the secretion of these humours, (perhaps even the aqueous also,) the fringed extremities of the processes being venous, will carry on absorption of the stagnant, or vitiated products as follows: the cellulo-vascular fringes of the processes of the vitreous body will pump up the vitreous humour, while, from the connection of these processes with those of the choroid, the former will receive in their turn the nutritive elements for the restorative process of secretion. The processes of the choroid, from their pendent condition in the posterior chamber, are admirably adapted for the absorption of the aqueous humour also.

Such, then, is the nature of the facts, which, though they might be dwelt upon more discursively, are sufficient, we deem, to prove that structures so vascular, were unquestionably destined to fulfil the high office which we have assigned them.

[While we have cheerfully complied with the request of the talented young author of the above paper, by giving insertion to his interesting researches, we must express our inability to yield our convictions to the correctness of the deductions he has drawn from them. The far greater rapidity with which absorption takes place in the anterior than in the posterior chamber, appears to us to be fatal to the hypothesis, that the ciliary processes are destined for the function of absorption.

Those who are interested in the minute anatomy of the eye, will find a most admirable account of it in Todd and Bowman's Physiological Anatomy, now in the course of publication. See *Med. News and Library, for Sept. and Oct.* 1847.—EDITOR.]